**Input data sets for different models**

**Data Set:**

It is a collection of data. In the case of tabular data, a data set corresponds to one or more database tables, where every column of a table represents a particular variable, and each row corresponds to a given record of the data set in question. The data set lists values for each of the variables, such as height and weight of an object, for each member of the data set. Each value is known as a datum. Data sets can also consist of a collection of documents or files.

In the open data discipline, data set is the unit to measure the information released in a public open data repository. The European Open Data portal aggregates more than half a million data sets. In this field other definitions have been proposed, but currently there is not an official one. Some other issues (real-time data sources, non-relational data sets, etc.) increases the difficulty to reach a consensus about it.

**Input Data Set:**

It is a computer file that contains data that serve as input to a device or program.

**Crop Growth Models:**

Crop growth models are computer software programs that can simulate daily growth (e.g. biomass, yield) and development (e.g. emergence, flowering, harvest) of crops.

Different models are enlisted below that are specially designed for this purpose,

1. APSIM
2. DSSAT
3. AgroMetShell
4. Aquacrop
5. CERES-Wheat
6. CROPGRO-Soybean
7. Cropsyst

**1) APSIM**

The Agricultural Production Systems Simulator (APSIM) is internationally recognized as a highly advanced platform for modelling and simulation of agricultural systems. It contains a suite of modules that enable the simulation of systems for a diverse range of plant, animal, soil, climate and management interactions. APSIM is undergoing continual development, with new capability added to regular releases of official versions. Its development and maintenance are underpinned by rigorous science and software engineering standards. The APSIM Initiative has been established to promote the development and use of the science modules and infrastructure software of APSIM.

**Input Data Requirement of APSIM**

An APSIM simulation is configured by specifying the modules to be used in the simulation and the data sets required by those modules. APSIM modules typically require initialization data and temporal data as the simulation proceeds. Initialization data is usually categorized into generic data (which defines the module for all simulations) and simulation specific parameter data such as site, cultivar and management characteristics. Typical site parameters are soil characteristics for soil modules, climate measurements for meteorological modules, soil surface characteristics and surface residue definition. Management is specified using a simple language to define a set of rules, calculations and messages to modules that are used during the simulation.

Data is currently stored in keyword free format grouped into sections stored in text files. Keyword format is in the form keyword\_/value (units)! description, sections are defined by a section header of the form (*data name. module name. parameter\_ type*). The order of keywords and location of sections is defined by the user. Temporal data such as climate and observed measurements are stored in free format columns headed with parameter names and units. The order of columns is arbitrary. A configuration file specifies the modules to be used in the simulation and a control file specifies each simulation with associated data files and section names for each module locate its data.

**2) DSSAT**

The Decision Support System for Agrotechnology Transfer (DSSAT) is a set of computer programs for simulating agricultural crop growth. It has been used in over 100 countries by agronomists for evaluating farming methods. ... Many common crops have their characteristics already implemented as DSSAT modules.

**Input Data Tools**

Most researchers have their own individual standard methodology for recording experimental data in field books, spreadsheets, and other electronic media. These individual differences make it somewhat challenging to convert the measured data into a format that can be directly applied in a crop modeling system. DSSAT, therefore, provides specific tools for entering weather, soil, crop management, and observational data.

**For Operation of Model**

1. **Site**

Latitude and longitude, elevation; average annual temperature; average annual amplitude in temperature, slope and aspect;Major obstruction to the sun (e.g. nearby mountain); drainage (type, spacing and depth); surface stones (coverage and size)

1. **Weather:**

Daily global solar radiation, maximum and minimum air temperatures, precipitation

1. **Soil:**

Classificationusing the local system and (to family level) the USDA-NRCS taxonomic system, basic profile characteristics by soil layer: in situ water release curve characteristics (saturated drained upper limit, lower limit); bulk density, organic carbon; pH; root growth factor; drainage coefficient

1. **Initial conditions**

Previous crop, root, and nodule amounts; numbers and effectiveness of rhizobia (modulating crop) Water, ammonium and nitrate by soil layer

1. **Management:**

Cultivar name and type, Planting date, depth and method; row spacing and direction; plant population, Irrigation and water management, dates, methods and amounts or depths, Fertilizer (inorganic) and inoculant applications, Residue (organic fertilizer) applications (material, depth of incorporation, amount and nutrient concentrations), Tillage, Environment (aerial) adjustments, Harvest schedule.

**For Evaluation of Models**

Date of emergence, Date of flowering or pollination (where appropriate), Date of onset of bulking in vegetative storage organ (where appropriate), Date of physiological maturity, LAI and canopy dry weight at three stages during the life cycle, Canopy height and breadth at maturity, Yield of appropriate economic unit (e.g. kernels) in dry weight terms, Canopy (above ground) dry weight to harvest index (plus shelling percentage for legumes), Harvest product individual dry weight (e.g. weight per grain, weight per tuber), Harvest product number per unit at maturity (e.g. seeds per spike, seeds per pod), Harvest product number per unit at maturity (e.g. seeds per spike, seeds per pod), Soil water measurements vs. time at selected depth intervals, Soil nitrogen measurements vs. time, Soil C measurements vs. time, for long-term experiments, Damage level of pest (disease, weeds, etc.) infestation (recorded when infestation first noted, and at maximum), Number of leaves produced on the main stem, N percentage of economic unit, N percentage of non-economic parts.­­­

**3) AgroMetShell**

The AgroMetShell is new tool developed by FAOSD RN that provides a toolbox for agrometeorological crop monitoring and forecasting. It is a user-friendly tool with a “visual menu” that offers easy access to some of the most often used functions. It also offers another choice of using a “pull down” menu. All the buttons in the visual menu have their equivalent in the main pull-down menus. For instance, the top left button on the visual menu in the DATA INPUT box can also be accessed by using the pull-down menu as follows:

The programme includes a database that holds all the weather, climate and crop data needed to analyses the impact of weather on crops. Data can be input into the database using a variety of options, for instance, they can be:

• typed in from the keyboard,

• read from WINDISP format images or

• imported from ASCII files.

**Input Data requirement**

**AMS input Files**

To run any model or computer programme, data availability forms an important component of the whole process. The data requirement of AMS are quite reasonable when you compare it to other heavy-duty models for crop simulation. There are basically 10 input files that one needs, to be able to run a water balance model in AgroMetShell as shown below. However, it may not be necessary to have all the input files listed depending on the circumstances. These circumstances may be that you are unable to calculate evapotranspiration on a dekadal basis and hence preparing an evaporation file may be difficult and one has no option but to use the normal evapotranspiration file. However, should the data be available, AMS has extra tools among which the tool to calculate evapotranspiration is one of them. There are also instances where the monitoring is done for rain-fed crops and therefore it may not be necessary to have a file on irrigation.

This basically reduces the number of files to run the water balance to 5 input files. Every time the user requests a water balance calculation to be carried out, the programme prepares a set of files that will be read by the Crop Specific Soil Water Balance programme to compute the water balance variables (such as soil moisture, actual evapotranspiration over the vegetative phase or the water stress at flowering, etc.).

The files required are in comma-separated quoted string format and can be directly imported into a spreadsheet. All the files will have common data in the first four columns which will contain:

• "NAME", the station Name

• "LON", the longitude in decimal degrees

• "LAT", the latitude in decimal degrees

• "ALT", elevation above sea level

**Input 1:** Country Name\_2003\_Crop\_Dekad\_Input.dat

The file contains a summary of the parameters used to run the water balance, including the following:

• "WHC", soil water holding capacity

• "Efrain", effective rain (a percentage by which actual rain is multiplied to assess actual water supply. Usually Efrain<100% on slopes and Efrain>100% in low lying areas

• "Crop-ID#", the internal identification number of the crop

• "Cycle", the cycle length in dekad

• "Pldek", the planting dekad, a value between 1 and 36

• "Irrig", the type of irrigation (1=yes, 0=no and 2=automatic)

• "BundH", the height of the bund, for irrigated crops

• "k1","k2","k3","k4"…. Up to the value corresponding to the last dekad of the cycle, crop coefficients KCP.

**Input 2 and 3:** Country Name\_2003\_Rain\_Dekad\_Input.dat

Country Name\_2004\_Rain\_Dekad\_Input.dat

The two files have actual rainfall for two consecutive years, as it often occurs that the crop is planted in one year and harvested in the following one. This kind of situation is what happens in southern Africa where rainfall commences in September/October of one year and terminates in April/May of the following year. However, in situations where an agricultural season falls within a calendar year, AMS will still work.

**Input 4 and 5:** Country Name\_2003\_Irrigation\_Dekad\_Input.dat

Country Name\_2004\_Irrigation\_Dekad\_Input.dat

The files contain actual values only if they have actually been provided. In monitoring rain-fed crops, this may not be necessary.

**Input 6 and 7:** Country Name\_2003\_PET\_Dekad\_Input.dat

Country Name\_2004\_PET\_Dekad\_Input.dat

The two files have actual potential evapotranspiration for two consecutive years, as it often occurs that the crop is planted in one year and harvested in the following one. Evapotranspiration plays an important role in the water balance as it represents the atmospheric demand.

**Input 8 to 10:** Country Name \_Normal\_Rain\_Dekad\_Input.dat

Country Name \_Normal\_PET\_Dekad\_Input.dat

Country Name \_Normal\_Irrigation\_Dekad\_Input.dat

The files contain normal rainfall, PET and Irrigation. The data from these files is utilized if the actual data is missing in the input files.

**4) AquaCrop**

AquaCrop is a crop growth model developed by FAO’s Land and Water Division to address food security and assess the effect of the environment and management on crop production.

**Input Requirement**

AquaCropuses a relatively small number of parameters and fairly intuitive input variables, either widely used or largely requiring simple methods for their determination. Input consist of weather data, crop characteristics for the specific cultivar and tuned to the environment, soil characteristics, and management practices that define the environment in which the crop will develop. The input is summarized schematically in Figure 1.3. The inputs are stored in climate, crop, soil and management files and can be easily retrieved from *AquaCro*p’s data base and adjusted through the user interface.

1. **Weather Data**

For each day of the simulation period, AquaCrop requires minimum (Tn) and maximum (Tx) air temperature, reference evapotranspiration (ETo) as a measure of the evaporative demand of the atmosphere, and rainfall. Additionally, the mean annual CO2 concentration has to be known. Temperature affects crop development (phenology), and when limiting, growth and biomass accumulation. Rainfall and ETo are determinants for the water balance of the root zone and air CO2 concentration affects biomass water productivity (WP\*). ETo is derived from weather station data by means of the FAO Penman-Monteith equation (as defined in the Irrigation and Drainage Paper N° 56). An ETo calculator is integrated in AquaCrop for that purpose. The climatic data can be given in a wide variety of units, and procedures are available in the calculator to estimate missing climatic data.

The daily, 10-daily or monthly air temperature, ETo and rainfall data for the specific environment are stored in climate files from where the program retrieves data at run time. In the absence of daily weather data, the program invokes built-in approximation procedures to derive daily temperature, ETo and rainfall from the 10-daily or monthly means. For rainfall, with its extremely heterogeneous distribution over time, the use of 10-daily or monthly total rainfall data might strongly reduce the accuracy of the simulations. The use of daily rainfall data is strongly recommended. Additionally, an historical time series of mean annual atmospheric CO2 concentrations measured at Mauna Loa Observatory in Hawaii, as well as the expected concentrations for the near future are provided in AquaCrop. The data is used to adjust the WP\* to the CO2 concentration of the year for which the simulation is running. The user can load or enter other future year’s CO2 for prospective analysis of climate change.

1. **Crop Characteristics**

Although grounded on basic and complex biophysical processes, AquaCrop uses a relatively small number of crop parameters describing the crop characteristics. FAO has calibrated crop parameters for major agriculture crops, and provides them as default values in the model. When selecting a crop its crop parameters are downloaded from the Data base. Distinction is made between conservative, cultivar specific and less conservative parameters:

- The conservative crop parameters do not change materially with time, management practices, or geographical location. They were calibrated with data of the crop grown under favourable and non-limiting conditions and remain applicable for stress conditions via their modulation by stress response functions. As such the conservative parameters require no adjustment to the local conditions and can be used as such in the simulations;

- The cultivar specific and non-conservative crop parameters might require an adjustment when selecting a cultivar or environmental conditions different from the one considered for crop calibration. The non-conservative crop parameters are affected by planting, field management, conditions in the soil profile, or the weather (especially when simulating in calendar day mode). These parameters might require an adjustment after downloading to account for the local variety and or local environmental conditions.

When a crop is not available in the data bank, a crop file can be created by specifying only the type of crop (fruit or grain producing crops; root and tuber crops; leafy vegetables, or forage crops) and the length of its growth cycle. On the basis of this information AquaCrop provides defaults or sample values for all required parameters. In the absence of more specific information these values can be used. Through the user interface the defaults can be adjusted.

1. **Soil characteristics**

The soil profile can be composed of up to five different horizons of variable depth, eachwith their own physical characteristics. The characteristics are the water retention in thefine soil fraction at saturation (θsat), field capacity (θFC), and at permanent wilting point(θPWP), and the hydraulic conductivity of the soil at saturation (Ksat). The user can makeuse of the indicative values provided by AquaCrop for various soil texture classes, or import locally determined or derived data from soil texture with the help of pedo-transfer functions. The presence of gravel (which reduces the plant available water), and the penetrability (which might limit root zone expansion) are other soil profile characteristics. The soil description is completed by specifying the depth and salinity of the groundwater table and its variation in time.

1. **Management Practices**

Management practices are divided into two categories: field management and irrigation management practices:

- Under field management practices are choices of soil fertility levels, weed management, and practices that affect the soil water balance such as mulching to reduce soil evaporation, soil bunds to store water on the field, and tillage practices such as soil ridging or contours reducing run-off of rain water. The fertility levels range from nonlimiting to poor, with effects on WP, on the rate of canopy growth, on the maximum canopy cover, and on senescence;

- Under irrigation management the user chooses whether the crop is rainfed or irrigated. If irrigated, the user can select the application method (sprinkler, drip, or surface), the fraction of surface wetted, and specify for each irrigation event, the irrigation water quality, the timing and the applied irrigation amount. There are also options to assess the net irrigation requirement and to generate irrigation schedules based on specified time and depth criteria. Since the criteria might change during the season, the program provides the means to test deficit irrigation strategies by applying chosen amounts of water at various stages of crop development.

**5)** **CERES-Wheat**

The CERES-Wheat model simulates phenological development of the crop, growth of grains, leaves, stems, and roots; biomass accumulation based on light interception and environmental stresses; soil water balance; and soil N transformations and uptake by the crop. It has the ability to evaluate different options of water and nitrogen management for increasing yield of wheat. The model describes the progress through the crop life cycle using degree-day accumulation. The duration of growth stages in response to temperature and photoperiod varies between species and cultivars, and genetic coefficients are used as model inputs to describe these differences. The phenology component also simulates the effect of water or N deficit on the rate of life cycle progress (Singh et al., 1999). The model predicts daily photosynthesis using the radiation use efficiency approach as a function of daily irradiance for a full canopy, which is then multiplied by factors ranging from 0 to 1 for light interception, temperature, leaf N status, and water deficit. Growth of new tissues depends on daily available carbohydrate and partitioning to different tissues as a function of phenological stage, which is modified by water deficit and N deficiency stress indices. Leaf area expansion depends on leaf appearance rate, photosynthesis and specific leaf area. The soil water balance model computes the daily changes in soil water content of various soil layers as a result of infiltration of rainfall and irrigation, vertical drainage, unsaturated flow, soil evaporation, plant transpiration, and root water uptake (Ritchie, 1998). The soil has parameters that describe its surface condition and layer-wise soil water-holding and conductivity characteristics. The model uses an overflow or “cascading bucket” approach for computing soil water drainage when a soil layer’s water content is above the drained upper limit.

**Input Data Parameters:**

Input requirements for CERES-Wheat include weather and soil conditions, plant characteristics, and crop management. The minimum weather input requirements of the model are daily solar radiation, maximum and minimum air temperature, and precipitation. Solar radiation can be approximated from other observations, such as the number of sunshine hours, which is sometimes more readily available. Soil inputs include drainage and runoff coefficients, first-stage evaporation and soil albedo, water-holding characteristics for each individual soil layer, and rooting preference coefficients at several depth increments. The model also requires saturated soil water content and initial soil water content for the first day of simulation. Required crop genetic inputs are coefficients related to photoperiod sensitivity, duration of grain filling, conversion of mass to grain number, grain filling rates, vernalization requirements, stem size, and cold hardiness. Main management input information includes plant population, planting depth, and date of planting. If the crop is irrigated, the date of application and amount is required. Latitude is required for calculating day length. The model can use different weather, soils, genetic, and management information within a growing season or for different seasons in a single model execution. The model simulates phonological development, biomass accumulation and partitioning, leaf area index (LAI), root, stem, leaf, and grain growth, and the soil and plant water and N balance from planting until harvest maturity based on daily time steps.

**6) CROPGRO-Soybean**

CROPGRO-Soybean is a complex crop simulation model. 8. that considers different temperature and photoperiod sensitivities during different crop developmental. 9. stages and/or for different cultivars.

**Input Data Requirement:**

1. **Site Data:**

Longitude, latitude, elevation, average air temperature.

1. **Daily Weather Data:**

Max. temperature, mini. Temperature, solar radiation, rainfall, wind speed, relative humidity (morning), relative humidity (afternoon), dew point temperature, photosynthetic active radiation.

1. **Soil Characteristics:**

Soil texture, soil local classification, soil family SCS system, soil depth, color, moist, albedo, evaporation limit, drainage rate, photosynthesis factor, pH in buffer, plants per hill, seed rate, sowing depth, irrigation date, irrigation amount, methods of irrigation, fertilizer application date, fertilizer amount N, fertilizer type, fertilizer application method, fertilizer incorporation depth, tillage date, tillage implement, tillage depth.

1. **Harvest Date:**

Harvest, harvest stage, harvest components, harvest percentage.

**7) CropSyst**

CropSyst is a multi-year, multi-crop, daily time step cropping systems simulation model developed to serve as an analytical tool to study the effect of climate, soils, and management on cropping systems productivity and the environment. Emphasis has been placed on developing a user-friendly interface, providing links to GIS software, a weather generator, and other utility programs.

CropSyst simulates the soil water budget, soil plant nitrogen budget, crop phenology, canopy and root growth, biomass production, crop yield, residue production and decomposition, soil erosion by water, and salinity. These processes are affected by weather, soil characteristics, crop characteristics, and cropping system management options including crop rotation, cultivar selection, irrigation, nitrogen fertilization, soil and irrigation water salinity, tillage operations, and residue management.

**Input Data Requirement**

Five input data files are required to run CropSyst: Simulation Control, Location, Soil, Crop, and Management files. Separation of files allows for an easier link of CropSyst simulations with GIS software. Definitions, usage, and range of variation of all parameters required by Crop-Syst are given in the User’s Manual (Stockle and Nelson, 2000), and they are also available in the Help facility of the model interface. The Simulation Control file combines the different types of input files as desired to produce specific simulation runs. It specifies the start and ending day of the simulation and the crop rotation to be simulated, and sets the values of all parameters requiring initialization. Also, inputs to this file allow users to switch on/off the simulation of soil erosion, soil salinity, nitrogen and CO2 effects on crop growth, and to select soil water redistribution and runoff models.

The Location file includes information such as latitude, weather file code name and directories, rainfall intensity parameters, selection of ET models (Penman\_/Monteith or Priestley\_/Taylor) and associated parameters, and generalized information on wind for locations where daily wind data are not available.

The Soil file includes surface soil cation exchange capacity and pH for the estimation of ammonia volatilization, parameters for the SCS curve number approach (US Soil Conservation Service, 1972) for runoff calculation, and parameters for the Revised Soil Loss Equation (Renard et al., 1997) for erosion calculation. For each soil layer, thickness and texture must be specified. Based on this information, pedotransfer functions (Saxton et al., 1986) are used to calculate bulk density, volumetric water content at water potentials of \_/33 kPa (Field Capacity) and \_/1500 kPa (Wilting Point), and air entry potential and Campbell b value for the relationship between volumetric water content and water potential (Campbell, 1985). Whenever available, actual measurements instead of values estimated from texture can be used.

The Management file includes scheduled and automatic management events. Management events can be scheduled using actual date, relative date (relative to year of planting), or using synchronization with phenological events (e.g., number of days after flowering). Scheduled events include irrigation (application date, amount, and salinity concentration), nitrogen fertilization (application date, amount, source, and application mode), tillage operations, and residue management. The automatic event manager (irrigation and nitrogen fertilization) checks continuously the soil water and nitrogen content and it can be specified to provide management for maximum growth or to implement deficit strategies.

The Crop file allows users access to a common set of parameters to represent different crops and crop cultivars. This is a key feature of CropSyst. The file is structured in the following sections: phenology (thermal time requirements to reach specific growth stages), morphology (Maximum LAI, root depth, specific leaf area, leaf area duration, and other parameters defining canopy and root characteristics), growth (transpiration biomass coefficient, radiation-use efficiency, stress response parameters, etc.), residue (decomposition and shading parameters for crop residues), Nitrogen (defining crop N demand and root uptake), harvest index (unstressed harvest index and stress sensitivity parameters), salinity tolerance, and CO2-elevation response.

Crop parameters are the only input data that require calibration within a narrow range to properly represent specific crops and cultivars. However, those parameters defining the bulk of the crop response to the environment and management can be determined through field experiments. These parameters are the transpiration-biomass coefficient (Tanner and Sinclair, 1983), the radiation-use efficiency (Monteith, 1977), the specific leaf area, the stem/leaf partitioning coefficient, and the leaf area duration. In addition, thermal time requirements for different crop development stages can also be recorded from field observations. The basic experimental data set must include growing season evolution of biomass (leaves and stem), LAI, intercepted PAR, soil water, seasonal daily weather, total biomass at harvest and yield.

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